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ABSTRACT

Improvement in science teacher education has been called for by several scientists and science education organizations. The concept of synergy is suggested as a model for enhanced improvements in the overall preparation of science teachers due to positive interactions between groups responsible for science teacher education, scientists, and science educators. A 30-item Likert type survey was sent to scientists and science educators in Ohio and Georgia. This study determined that areas of strong agreement existed between the two responsible groups regarding some aspects of science education. For example, scientists and science educators both agreed that science teaching in high school and college were not the same. Areas of less agreement were identified that suggested increased interactions between the responsible groups could produce clarification among issues of importance. Scientists and science educators disagreed about offering different science classes for teachers of K-6 and for science majors. Clarification of issues where less agreement was indicated will be necessary for optimum efficiency of science teacher preparation. This study suggests specific areas where dialogue has the greatest chance for success. (Author/CW)

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Perceptions of Research Scientists and Science Educators Regarding Science Education: Call for Synergy

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# Perceptions of Research Scientists and Science Educators Regarding Science Education: Call for Synergy


## Abstract

Improvement in science teacher education has been called for by several scientist and science education organizations (NSF, FASEB, NSTA). The concept of synergy is suggested as a model for enhanced improvements in the overall preparation of science teachers due to positive interactions between groups responsible for science teacher education, scientists, and science educators. To determine if there was a common ground for dialogue between these two groups, a 30-item Likert type survey was sent to scientists and science educators in Ohio and Georgia. This study determined that areas of strong agreement exist between the two responsible groups regarding some aspects of science education. For example, scientists and science educators both agree that science teaching in high school and college are not the same. Areas of less agreement have been identified which suggest that increased interactions between the responsible groups could produce clarification among issues of importance. For example, scientists and science educators disagree when it comes to offering different science classes for teachers of K - 6 and for science majors. Clarification of issues where less agreement occurs is necessary for optimum efficiency of science teacher preparation to result from changing the requirements for teacher education such as those proposed by the Holmes group. This study suggests specific areas where dialogue has the greatest chance for success.

## Introduction and Need for the Study

Improvement in teacher education in all disciplines has been called for by national reports (National Commission on Excellence in Education. 1983, National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983). These national reports highlight science education as being an area specifically in need of improvement; indeed the situation in science education has been termed "crisis." Yager and Penick (1987) have suggested that some scientist's solutions to some aspects of the problem areas seem arrogant. Lanier (1986) states that as far as teacher education goes there is hostility felt in some schools of arts and sciences towards professors of education. Arrogance and hostility could be due to lack of communication between groups regarding problem situations.

Science educators are calling for the participation of scientists to help alleviate the crisis in science teacher preparation and for the improvement of science education in general (Skoog, 1985; Gardner, 1985; Aldridge & Johnson, 1984; Gabel, 1984). Some evidence exists to indicate that scientists want to participate in science teacher education (Federation of American Societies for Experimental Biology, 1984). Literature which calls for more interaction and involvement of scientists in science education improvement in general, is summarized in Table I.

To reiterate, extant literature is replete with calls for participation of scientists in science education improvement. Yager & Penick (1987) and Lanier (1986) have stated that there are problems of both arrogance on the part of scientists and hostility towards professors of education by some science faculty. Anderson (1983) has determined that self-perceived success in academic science is related to journal article productivity and professorial rank. There is no existing reward in higher education, in other words, for making efforts to improve "education," including the education of teachers.

## Rationale for the Study

No data exist on the perceptions of research scientists toward science education in universities that will be affected by the Holmes (1986) plan. Currently, more than 100 college and universities have adopted the Holmes plan which will change the way science teachers are prepared; an undergraduate degree in a discipline will be required before a person can enter the school of education. Thus prospective science teachers may spend even more time in science classrooms than they do currently, prior to becoming science teachers. Gardner (1985) has stated that college science teachers are the main role models for high school science teachers since high school science teachers take far more science classes than they do classes in education. She also says that the leadership for improvement in pre-college education must come from higher education.

## Purpose

The purpose of this study was to assess and compare perceptions of certain aspects of science education between the two groups who are responsible for science teacher education. It is felt that similar perceptions on issues of importance could imply similar levels of knowledge and/or understanding. It is inferred that if similar levels of perceptions can be identified, a concerns model for science teacher preparation can be developed along the lines of the Synergy model in Figure 1. The details of this model will become apparent from the discussion which follows.

## Theoretical Framework

Melear (1986) has described the concept of synergy as applied to a problem in science education. The concept is used as the theoretical framework in this paper and deals with synergy, the interaction between elements of a system, as shown in Figure 1. In this context, the elements are the scientists and the science educators working together to improve, in this case, science teacher preparation.

### Description of synergy

Interaction between constituents in/between systems is a well-known phenomenon in science. In the field of medicine, drug interaction resulting in positive, additive results of multiple drug dosage is usually desirable, while the reduction of individual drug effects is generally undesirable. An interaction can, in general, give two types of effects which are essentially opposite to each other.

1. A synergistic interaction is an additive effect. The result is greater than the effect of each of the elements in the system simply added together.

Example of SYNERGISM:

$$\text{Effect } (1 + 2) > \text{Effect } 1 + \text{Effect } 2$$

OR

$$1 + 1 > 2$$

2. An antagonistic interaction is a reduced effect. The result is counteraction of each individual effect. In pharmacology, individual drug effects are reduced. In addition, the interaction of the drugs can actually be detrimental to the system.

Example of ANTAGONISM:

$$\text{Effect } (1 + 2) < \text{Effect } 1 + \text{Effect } 2$$

$$1 + 1 < 2$$

The use of the synergy concept was the theoretical framework upon which to explain the results of this study in the comparison of responses that either showed agreement or disagreement. The elements in the system are the two responsible groups for science teacher education: scientists, and science educators. The theme of this paper suggests that part of the crisis that exists in science education could possibly be abated, if synergistic interactions could occur between scientists and science educators especially in formative experiences for science teachers.

The diagram in Figure 1 suggests that the two groups responsible for science teacher education, and thus responsible for much of science education, may have common areas of concern. This study determined that specific common areas of concern do exist between scientists and science educators.

Several assumptions were made including the idea that both scientists and science educators are concerned about science education in general and about the education of science teachers.

A possible outcome of this research could be the development of a concerns model for future research agenda program planning if common areas of concern can be identified. It is a thesis of this researcher that synergism in the science community can occur--between scientists, science educators and science teachers--if the goal of improving science education for all students can be the focus. Scientists' contributions are irreplaceable in conveying the nature of science to pre-service science teachers. Formative experiences are a significant predictor of teacher effectiveness. The literature in science education has documented that what science teachers presently do rarely resembles "scientific" endeavors.

## Objective and Design

The objective of the research was to obtain and compare the responses of scientists and science educators regarding issues of science education. Toward that objective a survey (Butts, 1983) was sent to a group of scientists and a group of science educators principally in Ohio and Georgia. Most of the group was known by the author. About half of the respondents were employed at The Ohio State University. About one-fourth were from a combination of Georgia State University the The University of Georgia. The rest were from various Eastern universities (Boston University, John Hopkins University, Virginia Polytechnic

Institute and from the National Science Foundation officers.

A research scientist was defined as a natural scientist working in academia. A college/university science educator was defined as a professor (any rank) who teaches professional education courses for prospective or practicing high school science teachers. Validity of Likert response items on the questionnaire was determined by a panel of experts which included professors of science education and evaluation, and math and science education doctoral candidates.

## Analysis and Discussion

The analysis of the data proceeded along the following lines. To begin with, the response data were treated as though they were continuous in order to facilitate the analysis and in view of the preliminary nature of this study. Statistics (mean and standard deviation) were calculated for the response data of each question from the scientists as well as from the science educators. These summary statistics are given in Table II, and the mean responses to the questions are plotted in Figure 2.

The results of the statistical analyses are in Table III. The summary given in Table III shows that the variability of responses differed for only 11 of the 30 questions. With respect to the analysis of the differences between the mean responses, which is essentially the heart of this study, significant differences were found for only 12 of the questions.

### Areas of strong agreement: synergy.

The most useful and hopeful information gained from the data analysis comes from examining the questions for which the responses were least different, between groups. Some of these questions are listed below. These questions (numbers 6, 28, and 29) address issues of science education in which synergy, as defined in this paper, has its greatest potential for the improvement of science education.

The questions are:

6. Science teaching is the same, whether in high school or college.

28. I believe that most people in our society understand science.

29. I believe that public school science education is important.

Both science educators and scientists answered question 6 at exactly the same level of 2.3. The level of 2.3 was of Likert type response between "strongly disagree" and "disagree." In this case, as in the other two examples, no difference implies a level of strong agreement.

Areas of less agreement: significantly different perceptions.

Other useful, albeit less hopeful, results gained from this study is identification of areas of less agreement between groups. Questions 4, 12, 23, and 24 are some of those which show significant differences in the mean responses between groups. Those questions are listed below:

4. I am satisfied with the science education that is offered in my state.

For the above question, scientists are less satisfied than science educators and the difference of the mean response is significant at the .01 level.

12. Science education majors take mostly education courses while in college.

This difference was also significant at the .01 level. It could illustrate that a misconception exists among scientists about the amount of science that is required of the science education major.

23. I have worked with at least one of the science education faculty members in a college or university.

There was, again, significant difference between the mean responses of the scientists and science educators on this question. A comparable question, however, for science educators working with scientists was not included on the questionnaire.

24. I believe that college science classes for teachers of grades K-6 should be different than college science classes for science majors.

Scientists disagree with the above statement while science educators agree with it. The responses were significantly different (p=.01). This question and question 12 are the most interesting areas of disagreement, in this author's view.

Interestingly, a multiple regression trial demonstrated that the only question which was a predictor was an experience item, number 19 in the questionnaire.

19. One or more of my friends teach science in middle school.

## Qualitative Analysis

Many of the respondents were quite vocal in their remarks on the questionnaire. Some of the remarks bear witness to the hostilities that Lanier and Yager & Penick refer to. Below are some of them from the scientists:

> I believe that elimination of colleges of education would be of major benefit. Otherwise, limits should be set on the number of "methods" courses taken and "content" courses should not be taught outside majors departments.

> To teach science one must know science first and then be able to teach. The current system has too many science education courses and too few science courses. The most dangerous science teacher is one that teaches well but knows no science.

> If you want to put education people in science classes the choice of education people is crucial.

There was also some misunderstanding of the term "science education" as indicated by remarks such as:

> Science education vs science major is not a well-defined distinction.

> I am a professor. Was I a science education major?

> Who is science education faculty?
> a. Those that teach physics, chem, biol, etc.
> b. Those that teach about teaching physics, chemistry, biology....
> c. Those that oversee the distribution of science courses which are taken by k-12 teachers
> d. Those that teach graduate students who will become professors in science departments.

> Science education is actually education flavored with science!

This last remark was not coded from a scientist or a science educator; I would like to think that either one could have said it ... onse to item 24):

> ome classes should be different, most should be ... e major classes. As you know, we don't always do a job at the University. Some advanced classes are so specialized and poorly taught that I don't think they'd

much benefit early grade teachers. One the other hand, all science teachers would benefit from some advanced classes and research experience.

## Summary and Implications

Areas of agreement were found between the two samples of research scientists and science educators. These areas of agreement can be compared to comparable and possible favorable interactions that can promote synergism between the two groups responsible for science teacher education. This is possible because "interaction," or close proximity of ideas, already exists. This "close proximity," whether between molecules in a chemical reaction or between human beings who agree on something, is necessary before synergy has the opportunity to occur.

If close proximity does not exist, as demonstrated in the results of this study by those questions which showed significant differences, then it is possible that non-synergistic interactions, or antagonistic ones, are taking place. This could partly explain why there is hostility among faculty and even the arrogance described by Yager & Penick (1987). It could also explain part of the crisis that exists in science education. Scientists and science educators are together responsible for the one common goal of preparation of science teachers. If the two responsible groups are not in strong agreement on many issues of importance in science education, then less than optimum outcomes may be the products. Some of those issues are illustrated by the items on this survey that showed significant differences. As Yager & Penick point out, understanding of the issues is important before resolution can occur. For many of the questions, science educators indicated by the strength of their responses, more importance to some of the issues. This is only natural; yet there are strong indications in the scientific community that scientists too are deeply concerned about improving science education for all students.

More explicitly, groups who are responsible together for a common goal (in this case, the education of science teachers) should also have this in common: knowledge about the outcome, both ideal and actual, of the group endeavor. For example, if scientists are not aware that science education majors take far more science courses than they do education courses, then this misconception needs to be addressed and then remediated.

In the case of question 24, research results that describe elementary teachers' feelings of inadequacy in their ability to teach science must be conveyed to scientists. Teachers of college science courses need to come to an understanding that science classes for non-science majors should be taught differently than classes for science majors. Elementary education majors take these classes; their feelings of anxiety could stem at least partly from their own learning experiences. In making explanations to teachers of college science, the reasons for anxiety among elementary school teachers of science must include an explanation of the differences in learning styles between elementary school teachers and science majors. Much work is still to be done in the area of identification of learning style characteristics of these two groups. It is also likely that basic learning differences exist, as well, between science majors and science education majors. If quantifiable data in a learning style profile format were available, however, scientists might understand and accept that courses for teachers, in some cases, need to be different than courses for majors in science, because there are measurable differences between the groups.

That areas of agreement as well as areas of disagreement exist between scientists and science educators is not a surprise. This study suggests specific areas where dialogue has its greatest chance of success--those areas identified in this study of strong agreement. It also suggests that there are some volatile issues that can only be addressed through dialogue, with the goal of clarification and resolution of differences, for the improvement of science teacher, and thus all, science education.

Future studies of scientist groups are being planned to determine if the results gained in this study hold true among diverse populations of the scientific community. In addition, a professional interaction index is being developed which will determine current levels and types of interactions between members of the science education community.

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TABLE I

Literature which suggests more interaction/involvement of scientists in science education improvement.

| Year | Sources | | |
|---|---|---|---|
| 1983 | NSB | Gardner & Yager | |
| 1984 | Gabel | Aldridge & Johnston (NSTA) | FASEB |
| 1985 | Skoog | Gardner | |
| 1986 | Lanier | Holmes | |
| 1987 | Linn | Yager & Penick | |

Table II. Statistical Summary of Findings

| Item Number | Scientists (N = 22) | | | Science Educators (N = 15) | | |
|---|---|---|---|---|---|---|
| | Number of Responses | Mean Response | Standard Deviation | Number of Responses | Mean Response | Standard Deviation |
| 1 | 14 | 2.8 | 1.5 | 14 | 2.4 | 2.0 |
| 2 | 14 | 2.6 | 0.9 | 11 | 1.9 | 2.0 |
| 3 | 21 | 2.2 | 0.9 | 13 | 2.9 | 0.9 |
| 4 | 22 | 2.3 | 1.1 | 14 | 3.0 | 0.7 |
| 5 | 21 | 2.3 | 1.0 | 15 | 3.0 | 0.8 |
| 6 | 21 | 2.3 | 1.1 | 15 | 2.3 | 1.1 |
| 7 | 21 | 2.0 | 0.9 | 15 | 2.8 | 1.1 |
| 8 | 22 | 1.9 | 0.8 | 15 | 2.4 | 1.1 |
| 9 | 20 | 2.3 | 1.0 | 15 | 3.6 | 1.2 |
| 10 | 19 | 3.7 | 1.4 | 15 | 4.1 | 0.8 |
| 11 | 20 | 3.3 | 1.4 | 14 | 4.3 | 0.8 |
| 12 | 20 | 3.8 | 1.2 | 15 | 2.7 | 1.1 |
| 13 | 18 | 3.9 | 1.1 | 13 | 2.9 | 1.0 |
| 14 | 15 | 3.7 | 1.3 | 14 | 3.6 | 0.8 |
| 15 | 17 | 3.4 | 1.0 | 15 | 3.0 | 1.0 |
| 16 | 17 | 4.1 | 1.1 | 15 | 3.8 | 2.1 |
| 17 | 17 | 3.4 | 1.1 | 15 | 4.2 | 2.0 |
| 18 | 19 | 4.3 | 1.3 | 15 | 4.7 | 1.0 |
| 19 | 19 | 4.2 | 1.1 | 15 | 4.7 | 1.0 |
| 20 | 22 | 3.6 | 1.7 | 15 | 4.1 | 1.0 |
| 21 | 22 | 5.0 | 0.7 | 15 | 4.4 | 1.0 |
| 22 | 22 | 4.2 | 1.5 | 14 | 4.8 | 1.6 |
| 23 | 22 | 4.0 | 1.6 | 14 | 5.1 | 0.9 |
| 24 | 21 | 3.2 | 1.6 | 15 | 4.5 | 1.2 |
| 25 | 21 | 2.5 | 1.4 | 14 | 3.4 | 1.2 |
| 26 | 18 | 4.4 | 1.4 | 14 | 3.2 | 2.2 |
| 27 | 18 | 4.1 | 1.2 | 15 | 3.2 | 2.1 |
| 28 | 22 | 1.7 | 0.9 | 15 | 2.2 | 0.9 |
| 29 | 22 | 5.6 | 0.7 | 14 | 5.5 | 0.7 |
| 30 | 16 | 3.4 | 1.0 | 12 | 4.0 | 1.0 |

TABLE III
Summary of Analyses

| Question Number | Difference of Variability of Response | More var.[a] | Difference of Mean Response | Higher Ave. Importance[a] |
|---|---|---|---|---|
| 1 | NS[b] | | NS | |
| 2 | ** | SE | NS | |
| 3 | NS | | * | SE |
| 4 | * | S | ** | SE |
| 5 | NS | | * | SE |
| 6 | NS | | NS | |
| 7 | NS | | * | SE |
| 8 | NS | | NS | |
| 9 | NS | | ** | SE |
| 10 | * | S | NS | |
| 11 | * | S | ** | SE |
| 12 | NS | | ** | S |
| 13 | NS | | * | S |
| 14 | * | S | NS | |
| 15 | NS | | NS | |
| 16 | ** | SE | NS | |
| 17 | * | SE | NS | |
| 18 | NS | | NS | |
| 19 | NS | | NS | |
| 20 | * | S | NS | |
| 21 | NS | | * | S |
| 22 | NS | | NS | |
| 23 | * | S | ** | SE |
| 24 | NS | | ** | SE |
| 25 | NS | | * | SE |
| 26 | * | SE | NS | |
| 27 | * | SE | NS | |
| 28 | NS | | NS | |
| 29 | NS | | NS | |
| 30 | NS | | NS | |

[a] S = Scientist
SE = Science Educator
[b]NS = not significant
* = $p$ .05
** = $p$ .01

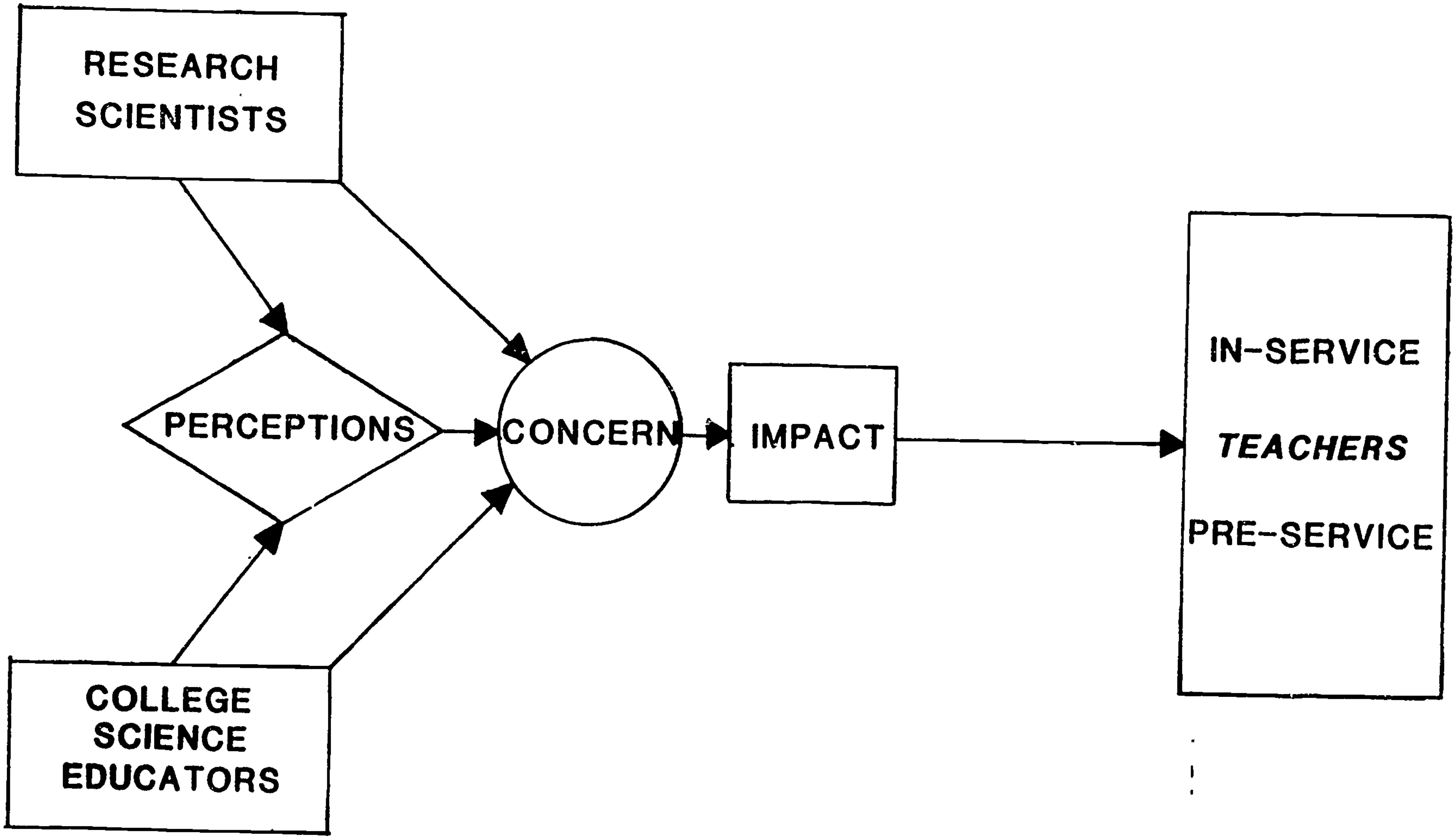


Figure 1. Synergy Model For Science Education Improvement.

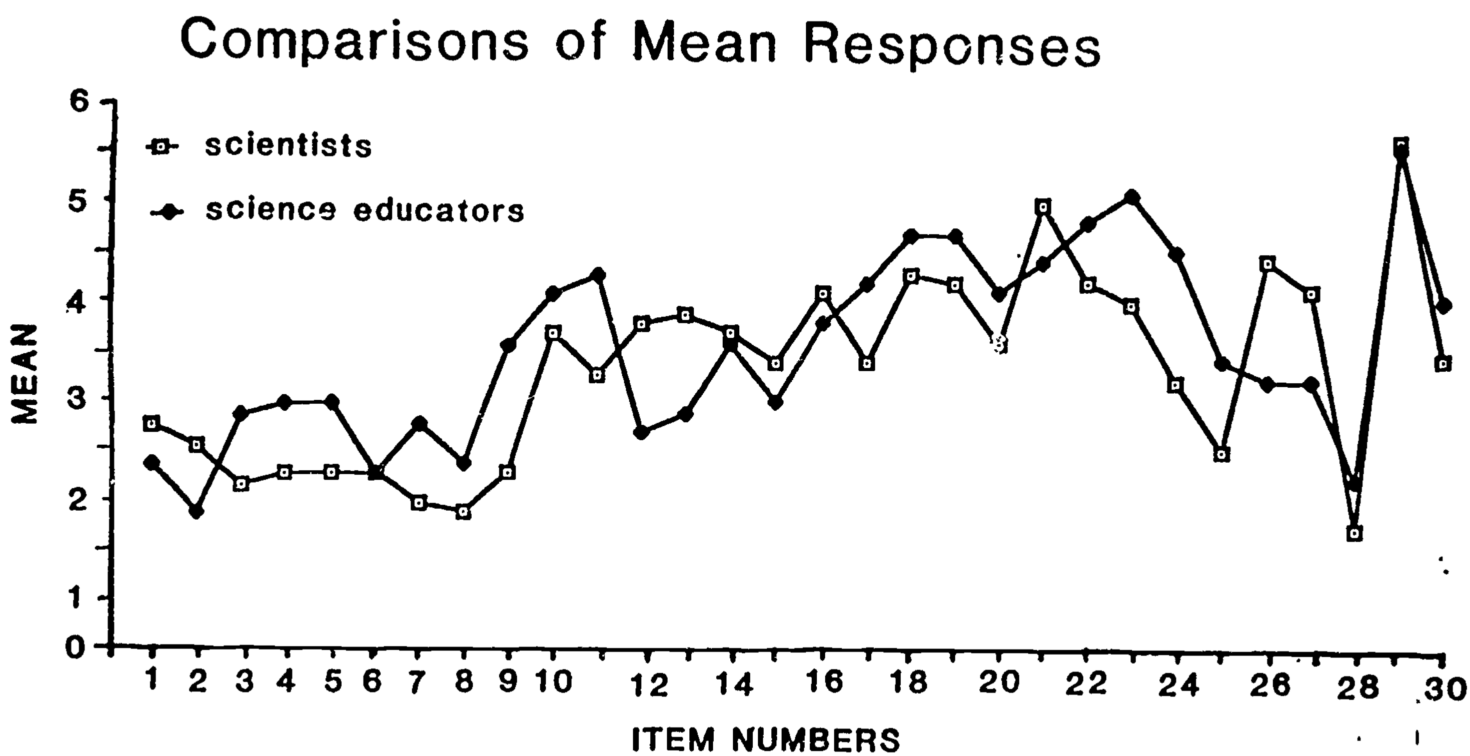


Figure 2. Mean Responses For The Survey Questions.